Man-Animal Interaction Complex in Goat Herding of the Pastoral Turkana

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MAN-ANIMAL INTERACTION COMPLEX IN GOAT HERDING OF THE PASTORAL TURKANA

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ABSTRACT

The developmental mechanism of mutual interaction between man and domestic animals is examined in the goat herding of the Turkana, nomadic pastoralists living in northwestern Kenya. Behavior and inter-individual relationships among the goats are studied. Comparison with non-managed, feral and wild goats, revealed several behavioral modifications induced in the domestic goats by human management: (1) individual differences in the degree of proximity to the mother; (2) familiarity among the members of one herd; (3) formation of large groups; and (4) learned ability to move autonomously during herding. The goats are totally habituated to human management. The behavioral changes in goats are an unintended secondary result of the management practices of separating the kids from their mothers by keeping the kids at the village, and of repeated day-trip herding. The relationship between man and domestic animals in certain management systems should be viewed as the integrated outcome of their mutual interactions.

INTRODUCTION

To analyze the relationship between man and domestic animals*1, from the viewpoint of mutual interaction, the researcher must carefully delineate the following two aspects of the animal's characteristics. First, domestic animals have been "subject to continuous control by man" (Hale 1969: 21) on their reproduction. Domestic breeding has resulted in various behavioral changes, as well as changes in physiological, ecological, and morphological traits. Domestic animals have historically undergone the process of modification under man's dominance. Secondly, domestic animals are presently kept under various management systems, and human cultural differences account for large behavioral variations within an animal species. For example, cows reared in a herd of several hundred controlled by a single herder on horseback in the New World are different from cattle set to work for cultivation in Southeast Asia and India, and from those kept in African pastoral societies. One can easily imagine that the behavioral diversity is caused by differences in management systems. Animals adapt to an artificial environment and submit to man's cultural regime (Krader, 1969).

As these points illustrate, domestic animals are distinct because they have come in contact with man. The first point stresses the peculiarity of animal species which have passed through a special process of modification, while the second point deals with the present behavioral variety in a species caused by cultural differences among human societies. Anthropological analysis should be attempted on the second aspect of the

man-animal relationship, while biologists research the first.

Tani (1976) has properly identified the stock management system as an inter-specific relationship of mutual interaction between man and animal. Relying on his analysis, I present a schematic representation of the origin of behavioral diversity of both man and animal (Fig.1). The behavior of domestic animals can be classified into two categories, managed behavior and non-managed or natural behavior. Managed behavior emerges as a result of management or man's behavior, while the natural behavior occurs in an animal species irrespective of management systems, and also in the wild or feral states. Although domestic animals may have acquired a great behavioral plasticity, this paper does not examine particular historical adaptations to an artificial environment. This paper discusses the present behavioral diversity brought about by conditioning, and excludes historical change and acquired plasticity.

On the human side of Fig.1, behavior (management) is classified into two categories, animal-oriented and human-oriented. In animal-oriented techniques, man makes concession to the animal's demands, and follows its behavior passively. In human-oriented management, man actively suppresses or modifies the animal behavior that may occur in a non-managed situation. The arrows on both sides of Fig.1 have a double meaning, indicating compromise and demand. The character of each animal species inherently demands certain fixed ways of human management, and yet a species behavior is also modified in some way or another by management. Similarly, man forces animals to obey his orders, but his management is under the constraint of the animal's characteristics. For example, herding time can be arranged in several ways: either man adjusts his daily life cycle to the animal's natural activity cycle, or man subordinates the animal to his cycle, or there is a compromise between both cycles (Tani et al., 1980).

The relationship between man and animal is complex. Ohta (in press) has pointed out that, in a large pasture where many farmers allow their cows to graze together, each family's cows have their own home range. This pattern of grazing is due to the management system. Each family's cows develop intimate bonds during the three winter months when they are kept in their owner's stable. Even though the people do not intend to modify the cow's behavior, they do exert influences. People developed the notion of home ranges which was named in a native term.

When the man-animal relationship is understood as a mutually influencing interaction, defects in the anthropological studies of stock management become clearly defined. Anthropological study has confined itself to how people manage animals, or man's side of the interaction. The nature of a particular management technique can not be understood until it is carefully analyzed with respect to its influence on the animals and

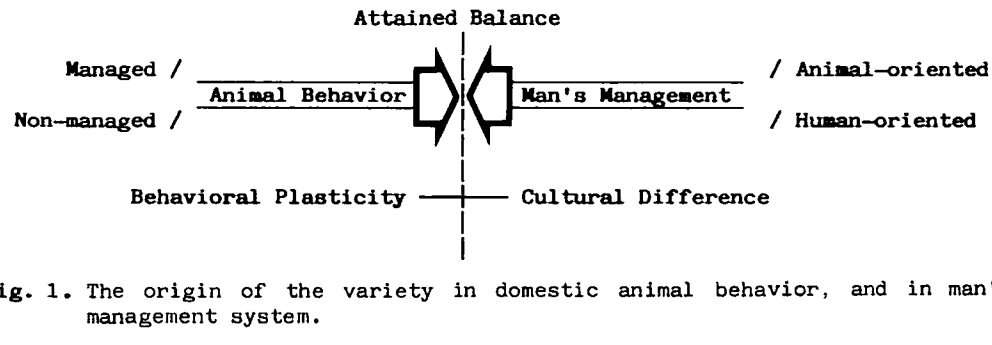

Fig. 1. The origin of the variety in domestic animal behavior, and in man's management system.

the way that the animal's behavior is modified. The animal's behavior should be contrasted to man's participation and compared with animal behavior in other management systems, and with the behavior in wild and feral states. It has been maintained, for example, that keeping calves at the human settlement, a common practice among pastoralists, prevents the herd of cattle from running away. However, the nature of this practice can not be understood without observing the cow's behavior, that is, the mothers really return by themselves, attracted by their calves, and lead the rest of the herd back to the settlement (Umesao, 1951).

Animal behavior has a distinct logic which is independent of man's intentions. To understand how the animals respond and compromise to man's management, their side of the interaction complex must be thoroughly examined.

This paper investigates the mechanism which characterizes the day-trip herding of goats among the Turkana*[1]. The goat's behavior and social relationships are described and analyzed in relation to human management system. What kinds of goat behavior contribute to the establishment of daily herding? What kinds of management techniques do the people practice?

The Turkana, Eastern-Nilotic language speakers (Gregersen, 1977), live in the arid land of northwestern Kenya. They are pastoralists, and depend almost entirely on livestock—cattle, camels, goats, sheep, and donkeys—for their food. I stayed about 8 km north of Kakuma, northwest of Lodwar, the administrative center of the Turkana District, Rift Valley Province. The study period was from August 1980 to January 1981.

OUTLINE OF DAY-TRIP HERDING

The Turkana herd their goats along dry riverbeds (Fig.2). When there

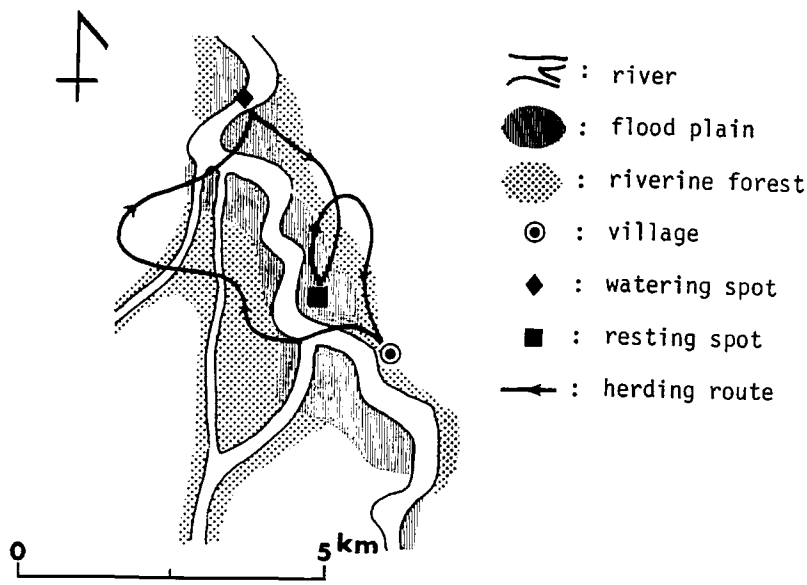

Fig. 2. Illustration of the herding area and an example of a day's herding route.

are heavy rains in the hills at the upstream, the river floods for a few days and then only a few scattered small pools remain. During the study period, goats could obtain water from pools from November 12 to December 28, 1980. In the rest of the period, people dug wells in the riverbed, from which they watered the goats once a day. People herded the goats out of the village in the morning, and drove them back into the village in the evening. The average herding time per day was 11 hours and 10 minutes (for the transition of herding time, see Appendix 1). Twice a day, for watering and rest, all the goats of a herd were gathered together. It took about 1.0-1.5 hours to water the goat herd and goats rested for 1.5-2.0 hours.

Vegetation in the herding area can be classified into three types (Fig.3). These types and the major plant species in each type are as follows:

(1) Flood plain: Calotropis procera and Acacia tortilis,
(2) Riverine forest: Acacia elatior, Acacia tortilis, Salvadora persica, and Cadaba rotundifolia.
(3) Outside the riverine forest: Cadaba rotundifolia and Dicliptera albicaulis.

Most of the Turkana's territory is semi-desert, with an annual precipitation of 200-400 mm. In this dry area, the flood plain and riverine forest are indispensable for goat herding, offering all the fundamental food plant species of goat's diet (for the goat food plants, see Appendix 2).

An example of herding route is shown in Fig.2. An average day's herding route covered approximately 15 km. During the study period, most of the herding time was spent in the flood plain and riverine forest. After the short rainy season, the herding area was expanded to the open plain outside the riverine forest where fresh grasses grew.

PROXIMITY RELATIONSHIPS AMONG THE GOATS DURING GRAZING

1. Aim and method

It is reasonable to assume that the goats of a particular herd*) exhibit a certain cohesiveness which contributes to the maintenance of the

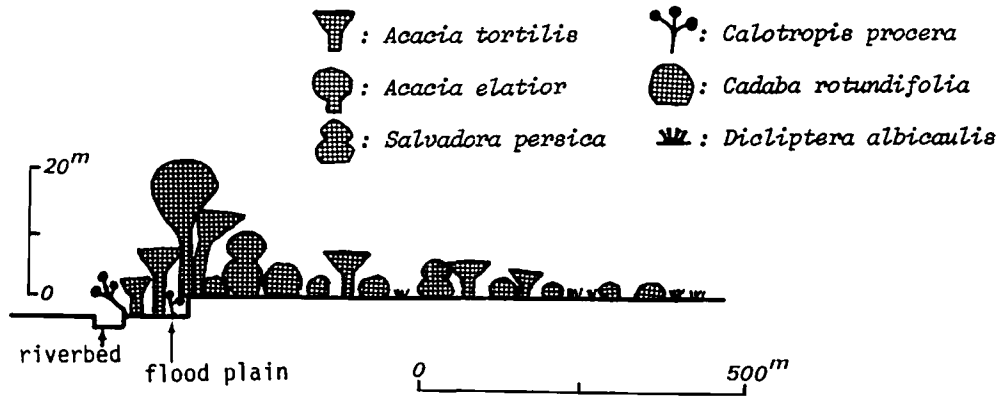

Fig. 3. Vegetation in the herding area (cross section).

herd. In this section, the social relationships within a herd are described and analyzed by group formation within the herd. This analysis is indispensable for the correct interpretation of the influences of man's management on the goat's behavior.

Table 1 shows the age-sex composition of the study herd. Any fluctuation in the composition of the herd members during the study period is ignored in the following analysis, because it had negligible influence on inter-individual relationships. Sheep within the goat herd are also ignored for the same reason (for goat classification, see Appendix 3).

Individual cards were made to identify 198 goats by appearance characteristics. The data were collected by focal animal sampling method for eleven goats (1 reproducing male, 3 castrated males, 6 parous females, and 1 young matured nulliparous female). Goats within a 10-meter radius of the focal animal were recorded at 5 minute intervals. In the course of day-trip herding outside the village, goats assembled in a cluster, either by themselves or under the herder's command, when they were near the village, the watering spot, and the resting spot. At other times, they spread out and grazed. Therefore, the goats alternated between two phases, the "phalanx phase" and the "spread-out phase." This classification is important because the focal animal sampling data were collected only when goats were in the spread-out phase.

2. Assemblage size

Table 2 reveals three main points about the assemblage, which indicates the group of goats within a 10-m radius of the focal animal. First, the assemblage size varies from 1 to 32 (including the focal animal) and averages 6.62. The goat's dispersion pattern is examined based on the total number of animals within a 10-m radius. The actual distribution significantly differs from the expected zero-truncated Poisson series (χ^2= 954.57, df=13, $p<0.001$; for the calculation, see Takasaki, 1981). It is suggested that the goat's aggregation pattern follows a contagious distribution.

Secondly, the cohesiveness of the goat groupings is different according to whether they are in the closed area or in the open area. The closed area is inside the riverine forest and flood plain, while the open area is outside the riverine forest (see Fig.2). For both cases in which castrated males and parous females were focal animals, there were more goats in the assemblage in the open area and fewer in the closed area (Mann-Whitney

Table 1. Age-sex composition of the study herd

Category of goat	No.
M : reproducing male	5
Mc: castrated male	20
Mm: matured male not castrated	12
My: young immature male	14
F : parous female	72
Fm: matured nulliparous female	57
Fy: young immature female	18
total	198

Fluctuations in the composition of the herd during the study period are as follows; 13 goats were transferred or slaughtered, 3 entered the herd, and 2 of these were slaughtered. For the details, see Appendix 3. 8 sheep were herded with the goats at the beginning of the study period, and 5 at the end.

U-test, $p<0.001$ in both cases). In the open area, the goats clustered more tightly. They seemed to be nervous and uneasy when there was no cover.

Thirdly, the assemblage size varies with the category of each focal animal. The analysis is limited to the closed area because the reproducing male (D2) and the young matured nulliparous female (K11) were observed only in the closed area. Castrated males were found in larger assemblages than the reproducing male. Parous females stayed in smaller assemblages than young matured female. The result of statistical comparison of assemblage sizes in closed area is as follows:

Fm=Mc, Mc>M, Fm>F, Mc>F, Fm>M, F=M (Mann-Whitney U-test, =:non-significant, >:significant at $p<0.001$).

It is concluded that the relationship among assemblage sizes for four

Table 2. Number of observations classified by the number of goats within a 10-m radius of focal animals

# \ focal animal	number of observation															
	M	Mc			F						Fm	total	Mc		F	
	D2	31	E1	I11	F1	F2	I2	I31	R1	X1	K11		0	C	0	C
0	5	5	2	2	14	2	5	2	4	9	1	51		9	1	35
1	16	10	3	4	17	6	2	13	10	11	4	96		17	4	55
2	10	3	8	6	14	6	2	16	8	22	9	104	1	16	2	66
3	12	8	11	7	13	10	4	9	12	11	8	105		26	3	56
4	12	9	8	11	23	7	5	12	4	8	15	114		28	1	58
5	7	7	16	6	10	19	3	14	11	19	16	128	4	25	11	65
6	8	4	13	8	10	11	5	9	5	12	11	96	3	22	7	45
7	3	1	9	11	12	18	2	10	2	4	8	80	2	19	14	34
8	3	4	11	10	7	15	2	6	5	5	6	74	6	19	12	28
9	1	1	7	9	5	5		1	7	5	12	53	6	11	8	15
10	2	2	6	5	4	6	1	2	4	2	2	36	4	9	11	8
11		5	1	3	2	4	1	1	6		5	28	3	6	9	5
12	2	2	2	5	1	5	1	1	2		2	23	4	5	5	5
13		1		1	1		1	1	1	4	1	11	1	1	2	6
14		1		1	4	1			1		1	9	1	1	4	2
15		1	1	3	2						2	9	2	3		2
16		2				1	1					4		2	1	1
17			1	2	2		1			1	1	8	3		1	3
18			1	1		1		1				4	1	1	1	1
19			1	3							1	5	2	2		
20			1								1	2	1			
21			1			1		1				3	1		1	1
22				1						1		2		1		1
	31,1	28,1		24,1								24,1				24,1
		31,1										28,1		28,1		
												31,1		31,1		
*	82	66	105	99	142	118	36	99	82	114	106	1049	45	225	98	493
**	332	356	720	743	702	761	192	466	437	511	676	5896	482	1337	807	2262
***	4.1	5.4	6.9	7.5	4.9	6.5	5.3	4.7	5.3	4.9	6.4	5.6	10.7	5.9	8.2	4.6

#, No. of goats in a 10-m radius; *, total number of observation; **, total goats observed; ***, mean No. of goats per observation; O, observation in open area; C, observation in closed area.

categories is: Fm=Mc>F=M.

When the assemblage size of castrated males and parous females are compared in the open area, the same result is obtained. The castrated males are found in larger assemblages than the parous females (Mann-Whitney U-test, $p<0.01$).

3. The social relationships among males

Large males were defined as those males with a shoulder-height exceeding 70 cm. There were 19 large males (5 reproducing males and 14 castrated males) in the study herd and 4 were focal animals (B1, D2, E1, and I11). Other males will be referred to as small males.

When the focal animal was a large male, the number of times other large males were within the assemblage was significantly higher than other animals in the herd (Mann-Whitney U-test, $p<0.001$ for 4 large male focal animals, see Fig.4). Large males tended to follow one another and formed loose groups while grazing. In this point, there was no apparent difference between reproducing and castrated males. The assemblage of E1 and I11 included more number of large males in the open area than in the closed area ($\chi^2=5.62$, $p<0.02$, Table 3). Large males sought partners in their own category where they felt uneasy.

The partner categories of reproducing male (D2) and castrated males (B1, E1, and I11) are examined dividing those goats which appeared in their assemblages into two, large males and others (Table 3). Reproducing males choose large males as association partners more frequently than castrated males ($\chi^2=8.67$, $p<0.01$). Reproducing males lack adaptability to goats other than large males. Castrated males are pliable to associate even with females and small males, although they also seek partners more frequently in large males than in others.

There is no significant tendency that each large male, whether reproducing or castrated, grazes together with large males of either category ($\chi^2=0.18$, $p<0.70$). Large males associate with one another irrespective of castration. It is not clear whether each large male had his specific grazing partners, or he sometimes chose grazing partners at

Tabel 3. Large male focal animals: number and categories of goats in the assemblage

	focal animal							
	closed area					open area		
	M	Mc			average	Mc		average
	D2	B1	E1	I11		E1	I11	
(A)	82	66	85	74		20	25	
(B)	29	22	27	29		15	16	
(C)	70	61	88	64		44	54	
(B+C)/A	1.21	1.26	1.35	1.26	Σ(B+C)/ΣA 1.29	2.95	2.80	Σ(B+C)/ΣA 2.87
(D)	233	273	394	379		152	201	

(A), total number of observations; (B), total number of reproducing large males present within a 10-m radius; (C), total number of castrated large males present within a 10-m radius; (D), total number of goats besides large males present within a 10-m radius.

random. A particular proximity relationship seems to exist between B1, E1, Y1, and g1, since they were frequently found in the same assemblage (Fig.4).

Not all of the large males form one compact group. The mean number of large males in the assemblage, including the focal animal is only 2.29 in the closed area, and 3.87 in the open area (Table 3).

4. Mother-offspring proximity relationships

Some goats were frequently within the 10-m radius of a particuliar focal animal, while others were rarely near the target. For the female focal animals (Fig.5), the four families (matrilineally related individuals), of F1, F2, 12, and 131, were tested to see whether or not the proximity frequency of the family members to the focal animal was significantly higher than the frequency of others. The families of F2, 12, and 131 were not in significantly close proximity to them, although proximity frequency of F1's family to her was significantly high (Mann-Whitney U-test, $p<0.05$). When large males were excluded, limiting the family members to females and small males, the same result was achieved.

These results suggest that there are no cohesive family groups comprising all matrilineally related goats (or all related females and small males) while the animals are grazing. This conclusion is verified by

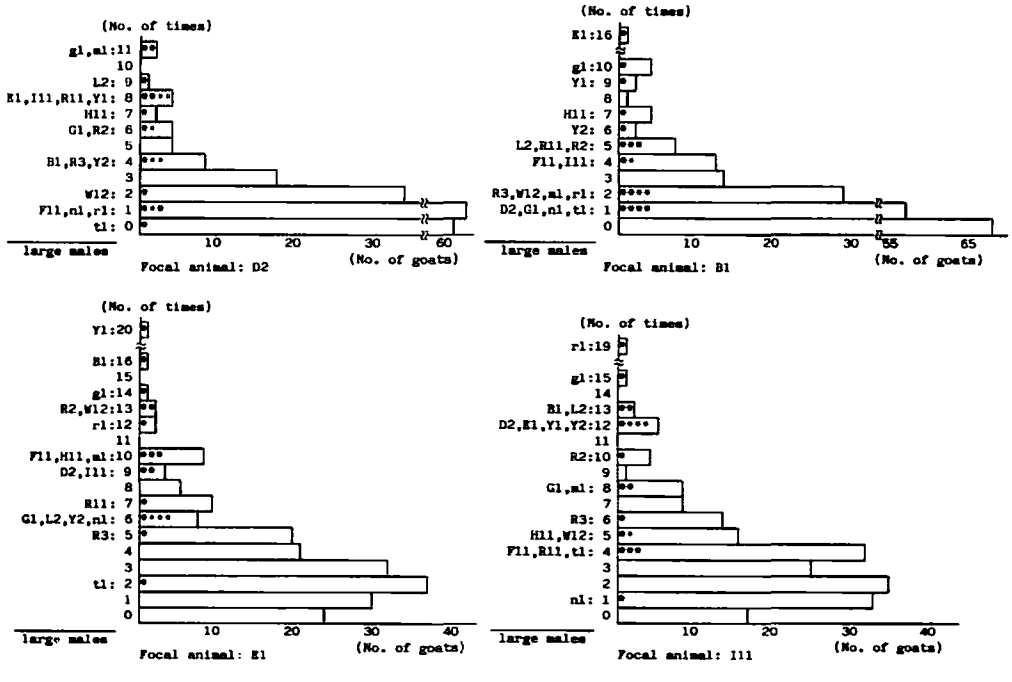

Fig. 4. Large male focal animals: number of goats classified by the number of times each goat was present within a 10-m radius.
The ordinate axis indicates the number of times each goat was present within a 10-m radius of the focal animal. The abscissa axis indicates the number of goats. *, large males.

the study of R1 and X1.

F2, F21, and F211 exhibited a proximity relationship covering three generations. Similar close proximity was observed between F1, F14, and F15. These were rare cases in which more than two goats form a grazing

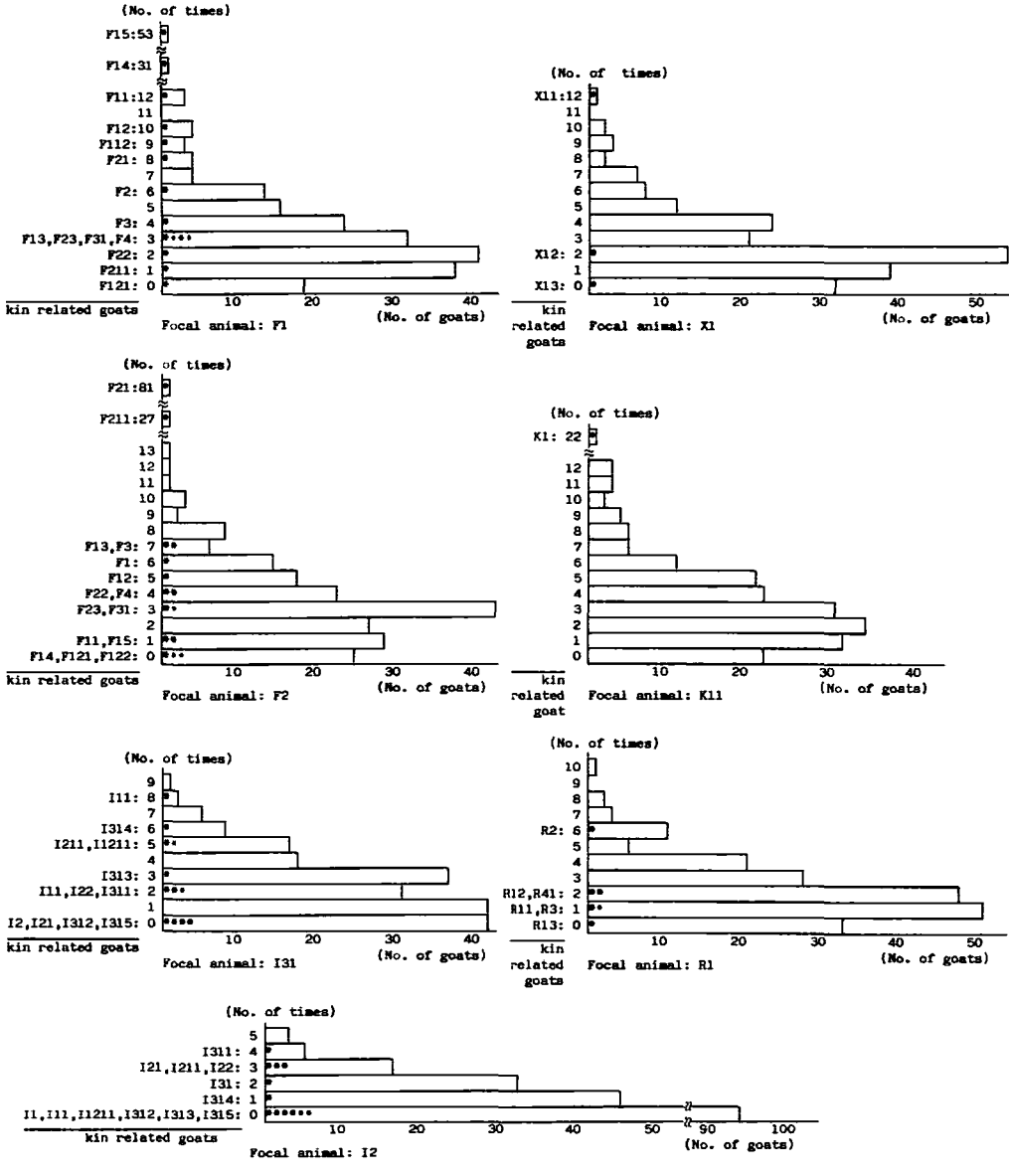

Fig. 5. Female focal animals: number of goats classified by the number of times each goat was present within a 10-m radius.
For both axes, see legend for Fig.4. *, kin related with focal animal.

group based on the mother-offspring relationship.

Next, the analysis was limited to the proximity between a mother and her offspring (for the individual symbols which indicate blood relationships among animals, see legend for Appendix 3). K11, a young matured nulliparous female, kept within close proximity of her mother. The mother was found within a 10-m radius of K11 in 20.8% of the total observation time (22/106). The same high frequency of mother-offspring proximity occurred between F1 and F15 (37.3%, 53/142), between F1 and F14 (21.8%, 31/142), and between F2 and F21 (68.6%, 81/118).

However, there was a difference in the degree of offspring's proximity to the mother. Although F14 and F15, which were twins, both kept in close proximity to their mother, F1, F15 stayed more frequently near their mother. For twins X11 and X12, X11 was often in close proximity to their mother, while X12 was never in their mother's assemblage. Furthermore, the offspring of I2, I31, and R1, were not in close proximity to them. I22, I314, I315, R12, and R13 were at the same age as (or younger than) F14, F15, and X11, but they did not graze close to their mothers. The mean ratio in which one offspring remained within a 10-m radius of the mother was only 0.10 (Table 4).

Among a mother's offspring, the youngest is not always in the closest proximity to the mother. F21, the eldest, was within F2's assemblage 81 times, while the younger F22 and F23 were close to F2 only 4 and 3 times respectively. The same was true of X1's offspring; X11 followed their mother while X13 did not.

5. Formation of parties

The term "party" is defined in this paper as a small group of goats which maintain continuous spatial positions while grazing. When the distance between two goats exceeds 50 m and there are no goats between them, they belong to different parties. Some examples of parties that goats made up in the spread-out phase are listed in Table 5. It has been suggested that goats exhibit a contagious distribution pattern when they spread out for grazing. The goats disperse into several small parties of many different kinds. Some are composed of only females, while others consist of both males and females. There is a party which includes only castrated males. Parties are very flexible and the goats band together and disband often without fixed rules.

The mean ratio indicating the probability that an offspring is in the same party as its mother is 0.12 (see the legend for Table 5). When at least one large male is present in a party, the mean number of large males in the party is 2.44. It is notable that these figures for parties are nearly the same as the results for assemlages which are obtained by focal

Table 4. Mean ratio in which one of the offspring is within a 10-m radius of its mother

	mother						mean
	F1	F2	I2	I31	R1	X1	
total No. of observation (A)	142	118	36	99	82	114	
total No. of offspring present in a 10-m radius (B)	97	88	6	11	2	14	
No. of offspring (C)	4	3	2	5	2	3	$\Sigma(B/A)/\Sigma C$
B/AC	0.17	0.25	0.08	0.02	0.01	0.04	0.10

Table 5. Examples of parties

party No.	goat category							total
	M	Mc	Mm	My	F	Fm	Fy	
1.					4	2	1	7
2.	1	4		3	13	7	1	29
3.					4	2		6
4.					6	2		8
5.	1	2	2	1	6	3		15
6.	2	4	1	4	18	5	6	40
7.				1	3	1	1	6
8.	2			5	1	4	4	16
9.					4	2		6
10.		1				2	1	4
11.					4	2		6
12.		1			8	9	2	20
13.		3	2	1	10	4	3	23
14.		1		1	4	6		12
15.	1	4			2	3		10
16.		1	2		7	5		15
17.		5	2	1	11	6	1	26
18.	1	3	1	1	6	8	3	23
19.	1	3	3	2	9	5	1	24
20.		3	1	1	3	2	1	11
21.		2						2
22.	1			2	6	4	1	14
23.	3				15	9	7	34
24.		3		2	9	9		23
25.		2			4	1		7
26.					2	3		5

For the categories of goats, see Table 1. The mean ratio in which one offspring was in the same party as its mother is calculated as follows: first, parties in which the mothers appeared are picked up. For each of their offspring, the number of parties in which the offspring and its mother both appeared (A), and the number of parties in which its mother was observed (B) were counted. A/B is the offspring's ratio of appearance in the same party as its mother.

animal sampling.

PROXIMITY RELATIONSHIPS IN THE KRAAL

A second study was made at the kraal where the goats slept. The Turkana constructed the kraal, about 11 m in diameter with a small enclosure for kids in a corner, at the center of the village. Data were collected in the evening after most of the goats sat down in the kraal. The position of 71 goats was recorded for 14 days (see Appendix 3 for the 71 sample goats).

The mean distance between goats in each category was compared with the mean distance between all 71 goats (Table 6). Large males sat in close proximity to one another and the mean distance between them was significantly shorter. The same result was obtained for family groups consisting of one mother and her offspring. However, the distance between mother and offspring in each pair must be examined (Table 7).

Table 6. Distance between individuals in the kraal (m)

goat group	n	N	mean distance	s.d.
all	71	34790	4.59	2.27
large males	19	2394	3.99**	2.40
F1	5	140	3.74**	3.42
F2	4	84	3.90*	2.47
I2	3	42	1.80**	1.93
I31	6	210	3.94**	2.57
K1	2	14	0.91**	1.65
R1	3	42	2.62**	1.90
X1	4	84	3.52**	2.55

F1, F1 and its offspring excluding large males; *, significant at $p<0.01$; **, significant at $p<0.001$, (T-test); n, No. of goats; N, No. of samples, $N=14n(n-1)/2$.

Table 7. Distance of each mother-offspring pair in the kraal (m)

mother	offspring	mean	s.d.	mother	offspring	mean	s.d.
F1	F12	6.94	2.58	I31	I311	1.02	1.03
	F13	2.60	2.56		I312	4.70	2.65
	F14	0.72	0.55		I313	4.96	2.54
	F15	0.64	0.43		I314	5.02	2.21
F2	F21	1.24	1.15		I315	0.90	0.91
	F22	4.71	2.41	R1	R12	3.18	1.44
	F23	3.94	2.72		R13	1.30	1.39
I2	I21	1.17	1.20	X1	X11	3.18	2.51
	I22	1.81	2.43		X12	1.99	2.61
					X13	4.63	1.99

N(sample No.)=14, for each pair.

Some goats which did not graze near their mothers did sit close to them in the kraal. These goats probably did not need to stay near their mothers for psychological stability while grazing, although they recognized their mothers. These goats were on a variety of individual developmental stages. I22 and I311 were parous females, F13, I22, I315, R12, and X12 were young matured nulliparous females, while R13 was a immature young male.

As in the case of grazing, it is important that there were individual differences in the degree of proximity to the mother in the kraal. F12, I311, and F21 were parous females with younger siblings. F12 did not sit near her mother while the other tended to sit close to their mothers. Although F14, F15, I315, and X13 were all young matured last born females, F14, F15, and I315 sat closer to their mothers than did X13.

The degree of proximity to the mother is independent of the developmental stages. For F1 and R1, the younger offspring sat closer to the mother, while for I31, X1, and F2, the elder offspring sat closer. It has been already pointed out that there were similar reversals in the degree of proximity to the mother when the goats were grazing.

THE HERDER'S CONTROL OVER THE HERD

1. Allocation of herders to the goat herd

Some herders accompany the herd on day-trips. They lead the herd to the watering spots and resting spots, and to better pastures. The herders also maintain control over the herd so that no goats will be lost.

Three herders attended the study herd of 198 animals, although one herder stopped working in the second half of the study period. Each herder had a role. The eldest youth (about 18 years old) positioned himself at the front of the herd, keeping the goats in a cluster, and chasing back those that proceeded too far ahead. Another herder (about 14 years old) was in charge of the rear of the herd, chasing forward those goats that lagged behind. When the herders drove the goats to the watering or resting spots, the younger herder made sure that no goats were delayed or lost. The third herder (about 10 years old), who stopped working midway in the study, did not have a specific position, but followed the instructions given by the elder herders.

When the herd changed directions, the eldest herder chased the lead goats toward the rear, and then moved through the herd to the new front of the herd chasing goats here and there. The second herder rounded up goats that strayed to the sides, chasing them in the new direction, and the goats gradually passed by until he was at the rear of the herd. It was also his duty to proceed zigzag at the rear of the herd to make sure that all the goats had shifted their direction and moving forward. This final check was necessary because the herders could not always see where the goats were scattering, especially in the riverine forest where the visibility was poor.

2. Amount of the time spent in controlling acts

The herders always carried one or two wooden sticks to herd the goats. They brandished them, threw them at the goats, and beat the bushes. Sometimes, thin, elastic branches were snapped off and used as whips. When the herders chased the goats, they yelled "hai, hai, hai," made sounds like "chi, chi, chi" by putting tongue on the roof of the mouth, and cursed the goats. They sometimes whistled to drive the goats forward.

The herders tried to command the goats by these actions. The amount of time spent in controlling the goats was examined. A herder (the second eldest boy) was followed all day and his activity was recorded. At certain times, it was difficult to judge whether or not he was really controlling the goats. Sometimes his mere presence seemed to influence the goat's behavior. A "controlling act" was recorded when his presence and actions seemed to produce a direct and concrete influence on the goats, including simply walking behind the goats. Sitting in the shade of trees watching the herd, walking toward the herd, and patrolling for the lost goats were not regarded as controlling acts. His behavior was recorded at 10 second intervals. In the statistical analysis, each interval was counted as one unit.

Table 8 shows the time the herder spent controlling the herd in two days. Herders frequently assume control of the goats in the 30 minutes after departure from and before arrival at the village, and in the 30 minutes before and after watering and resting. These times are referred to as Term A, in which the goats were usually in the phalanx phase, clustering together. During the rest of the time, Term B, the goats were usually in the spread-out phase.

Relatively little control is needed to manage the goats efficiently. The average time spent in controlling acts was 42 minutes and 20 seconds (254 units). The average herding time excluding watering and resting time was 532 minutes and 30 seconds (3195 units). On the two study days, there

Table 8. Amount of the time spent in controlling acts by a herder for one goat herd (10 seconds as the unit)

date (1981)	Term A control /total	Term B control /total	A+B control /total	watering & rest time	total herding time
Jan. 13	136 /1080 12.5%	70 /1992 3.5%	206 /3072 16.7%	798	3870
Jan. 23	203 /1080 18.8%	99 /2238 4.4%	302 /3318 9.1%	612	3990
average	169.5 /1080 15.7%	84.5 /2115 4.0%	254 /3195 7.9%	705	3090

For the discrimination of Terms A and B, see the text.

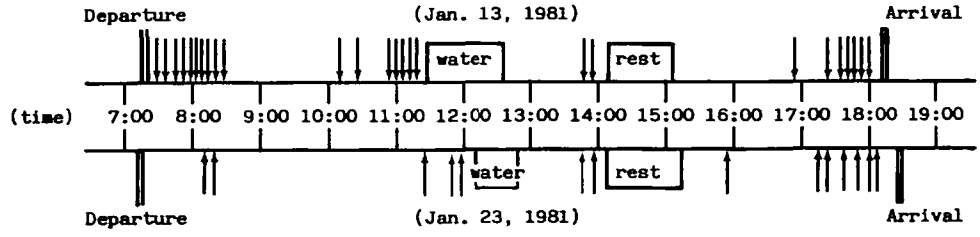

Fig. 6. Daily distribution of a herder's command.
Arrows, commands; A continuous controlling act is indicated by one arrow, irrespective of the span of the control.

were two herders. One herder can manage the herd if he spends 15.9% (254 ×2/3195) of the herding time in controlling acts, assuming that the two herders worked the same amount. There were more controlling acts in Term A and fewer in Term B (χ^2=133.72, $p<0.001$). Fig.6 shows that the controlling acts are concentrated in Term A. Only 8.0% (4.0×2) of Term B is needed to spent controlling the herd by one herder.

3. Amount of the time in which the goats are controlled

How much should a goat be controlled by herders to ensure that it is not lost? Again, it is difficult to judge accurately whether or not a goat is controlled by the herders because, as in the following example, the herders will exert influence on certain goats without direct intension of control. If a herder chases some goats 50 m away from goat Z, when the goats are in the spread-out phase, this action may not have any direct influence on Z. However, it is possible that Z would be indirectly controlled because Z will follow the goats chased by the herder if they approach Z as a group. Data measuring the amount of the time a goat was controlled, were collected during the focal animal sampling. The target goat was considered as controlled, when herders performed controlling acts within 30 m of it, regardless of the herders' intentions.

The focal animal is under the command of the herders only 3.2% (121 minutes) of the total Term B following time (3720 minutes). This time is enough to ensure that a goat is not lost in Term B when all the goats

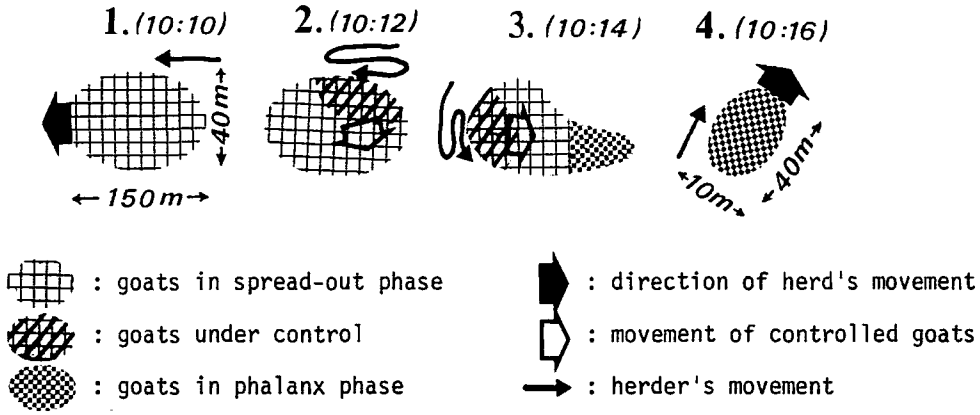

Fig. 7. An example of a herder rounding up the herd.

of a herd usually spread out for grazing.

4. The goat's response to herding

It is supprisingly easy to gather spread-out goats into a cluster, especially in the open area. Fig.7 indicates an example where one herder rounded up the entire herd and changed the goat's movement direction. He completed the round-up in only four minutes, although the herd was less spread out than usual. The herd was proceeding to the left in Fig.7 (1). The herder interfered in a part of the herd and chased goats (2). A part of the herd were forced to cluster together. The herder moved to another side of the herd and chased goats to the new direction (3). The total herd bunched up into a phalanx (4). He needed only to make a core for the aggregation in the center of the herd, and the goats gathered by themselves. The herders did not need tc chase each goat.

In the course of day-trip herding, goats frequently proceed in a certain direction by themselves. The following observation was made in the morning, when the goats were heading toward the watering spot.

> Observation 1: 30 Oct. 1980, 7:09. About one and a half hours after departure from the village. The goats are heading north (in the direction of the watering spot) in the riverine forest. A herder chases the head of the party. About 40 goats are forced to cluster, then chased south. 7:14, the goats walk about 20 m south and stop. They spread 30 m in diameter and some sit down. The herder (only one herder is present here) begins to eat berries of Salvadora persica. 7:20, a few of the goats start to walk north and the herder cries out, "hai, hai, shiiii...." He throws a piece of wood at the goats. The goats are scared and bunch up to run back to the cluster. 7:22, again, some goats start northward. The process of movement occurs slowly in the party, without a conspicuous leader, and all the goats begin to move gradually. 7:23, the herder stops eating berries, and begins to chase the goats back. He drives them for about one minute and then he returns to the berries. The goats, chased into a cluster, walk down about 50 m and stop. Some lie down again. 7:31, they move northward again. All the goats which are standing, raise their heads and look northward. The herder cries out from the berry tree 50 m north of goats. 7:35, most of the goats proceed north and the herder

interferes. He chases the goats southward for about two minutes. The goat's location is almost the same as it was at 7:14. 7:48, they move northward again. All of them apparently want to leave. The herder cries out while eating berries, but the goats do not stop. They proceed northwest in a line, without grazing. The herder remains collecting berries.

The goats insist on their own way. The character of the herder's control in this illustration is to delay the goat's movement.

FAMILIARITY AMONG THE GOATS OF A HERD

The herd is the basic unit of day-trips. The goats of a herd are managed as a group, grazing together and spending the night in one kraal. The association pattern of the goats strongly indicates that the members of a herd are familiar with one another. If the goats of one herd happen to meet goats of another herd while grazing, the animals will segregate into their respective herds without any command from the herders. Six observations which indicate familiarity among the goats, are described below. The study herd is referred to as Herd X and the other herds as Herds Y and Z.

Observation 2: 1 Nov. 1980, 10:37. In the flood plain. All the members of Herd X are heading southward, dispersing widely to about 300 m. Twelve goats which belong to Herd Y, which comprises about 150 animals, are standing together in a cohesive group. They have apparently strayed from the rest of Herd Y. The members of Herd X pass by this small group one after another. Some of the stray goats bleat, but they are ignored by Herd X. The Herd X goats are completely indifferent, and do not stop. On the other hand, Herd Y goats do not follow, but remain standing in their group.

As the next observations illustrate, the goats of different herds sometimes meet and mix together while grazing, but they then independently separate from each other.

Observation 3: 12 Nov. 1980, 8:46. Eleven goats of Herd X are proceeding northward slowly while grazing when they meet 5 goats of Herd Y. Five of the Herd Y are bleating, clustering tightly. From about 20 m to the south, a larger group of Herd Y is approaching, grazing intermittently and giving bleats in response. 8:51. The five goats remain standing while the goats of Herd X proceed northward. The confusion caused by the mixing of two herds is independently solved.

Observation 4: 12 Nov. 1980, 9:26. In the riverine forest near the water hole. Members of Herds X and Y seem to be inter-mixed, forming a group of about 40 goats. A herder of Herd Y enters the center of the group, and divides them into two clusters (about 25 and 15 animals each). From the group of 15 goats, five of Herd X (131, R1, Y31, e1, and x4) proceed in single file toward the group of 25 Herd X goats. The distance between the two groups is about 15 m and gradually increases without a command from the herder.

Observation 5: 12 Nov. 1980, 15:05. A herder of Herd Y chases 18 goats out of a bush, beating the bush with a stick. The goats are frightened and at first gather together tightly. Then, four (A21, n3, L11, and 11211) of Herd X leave the cluster, walking forward to a group of about 40 goats of Herd X, which is 40 m northwest. The remaining 14 goats of Herd Y are chased southward in a cluster by the

herder.

Goats discriminate members of their own herd from members of other herds, and prefer to associate with goats of their own herd. When one herd meets another, especially when the herd is moving as a pack, the goats frequently bleat. When bleats of distress are given by goats which become surrounded by another herd, responding bleats are given by the goats of the herd that have already passed. Such vocal communication occurs frequently between mothers and offspring. In a few cases, castrated males are also observed to respond to goats to which they are not related.

The observation below describes a rare situation in which a few stray goats found shelter with a different herd.

> Observation 6: 11 Nov. 1980, 13:15. Four goats of Herd Y are discovered in Herd X. The goats of Herd X are scattered widely for grazing. The four Herd Y animals assemble together, bleating continuously. A herder of Herd X comes to gather the goats (about 40 animals) together and takes them to the resting spot. (The goats rested until 14:30, and then spread out for grazing.) 16:15. The four Herd Y goats remain in Herd X, grazing at the periphery of the Herd X and obviously clustering more tightly than usual.

As mentioned earlier, the members of a herd spread and form several parties while grazing. The goats of small parties will sometimes follow the larger parties of different herd members. The goats seem to lose their sense of security when parties are too small, although their sense of security also depends on the age-sex composition of the party, and on the relationships among the members.

The tight clustering of small groups found in different herds indicates that they know which goats belong to their own herd and which do not. The goats followed by the members of different herds seem to ignore the strange goats. They neither respond to the bleats of the strays nor attack them.

The next observation was made at the resting spot when the goats of two herds rested at the same time. The owners of these herds set up one village together, although each independently kept his own kraal and herded goats separately.

> Observation 7: 12 Nov. 1980, 12:23. About 150 goats are chased by herders to the resting spot. They stop under the trees, segregating themselves into two groups about 30 m apart. From one of the two groups, which is composed mainly of Herd Z animals, some Herd X goats leave and approach the second group. C41, x1, and f32 are followed by R11, A51, x21, L1, V41, e3, a3, 122, x13, and W2 in turn. The goats of both groups sit down. Then, from the group of Herd Z goats, the rest of Herd X stands up (g1, N1, F122, 1313, 131, X1, R3, 1312, and R13), and approaches, and sits down with the second group. Thus, the segregation of the two herds is completed.

These two herds realized their spatial unity when they sat down. The sitting position of the two herds was almost fixed and they were distinct from each other. One herd was always located north of the other. It is suggested that the goats are able to discriminate their sitting spots.

DISCUSSION

1. Party size and herd controlling techniques

From Table 5, the party size in the spread-out phase averages 15.8 goats. The focal animal sampling data showed 6.62 goats in an

Table 9. Party size in domestic, wild, and feral goats

site	party size	source
Turkana	15.8 (party) 6.64 (assemblage)	
New Zealand	2-14 (av. 3.8)	Riney & Caughley (1959)
North Wales	3-6, up to 30	Crook (1969)
Hawaii	3-5 (male group) 2-4 (family group) 7.97*	Yocom (1967)
British Columbia	4-6 10-20**	Shank (1972)
Karchat	19 and 24***	Schaller (1977)
Chiltan	4.1 and 5.4***	Schaller (1977)
Ogasawara	3.8	Shikano (in prep.)

*, average size calculated from Fig.3, which does not include parties of one goat, in Yocom (1967); **, from Fig.3 in Shank (1972); ***, average sizes in different seasons.

assemblage. The party size of Turkana goats is larger than the size of wild and feral goat parties (Table 9). Turkana goats seem to aggregate more tightly because they are conditioned to the clustering by human management.

The Turkana goats cluster together in a group at the village, and at the watering and resting spots, as well as in the kraal at night. Instances of large group formation are also found among feral goats. For example, a group of more than 100 goats was observed in British Columbia (Shank, 1972). I also observed large groups of goats in Ogasawara Islands, Japan, a party of about 40 animals at Muko-jima, about 50 at Yome-jima, and more than 100 at Nakoudo-jima. Large parties are formed naturally when the population density is high, suggesting that goats are able to adjust their behavior under circumstances similar to being forced to form densely crowded groups by human management.

Large parties are also formed among feral and wild goats when they are frightened by dogs or humans and cluster together (Yocom, 1967). The Turkana controlling techniques effectively take advantage in this characteristic goat behavior, when herders surprise or scare their goats to control the herd. By brandishing sticks, and beating bushes with sticks, the herders can cause the goats to become psychologically unstable. Baskin (1974) stated that herd management among the pastoralists is primarily based on the defensive responses of the animals. The goats are forced to attend to one another's location and movement in order to cluster together, and any isolated goat will run into the group. The herders need only give a warning. In other words, the Turkana make full use of the goat's non-mamaged behavior in their management techniques.

2. Transition from specific individuals to unspecific individuals

Schaller (1977) used the term "herd" with the same meaning as word "party" used in this paper. He pointed out that among Caprinae species, "the herd structure of most species is similar, it being characteristically flexible, with only a mother and her young and sometimes a yearling, as well, forming a close bond.... Three kinds of herds exist in most societies: male herds, as well as some solitary males; female herds consisting of females, yearlings, and young; and mixed herds containing

adults of both sexes" (Schaller, 1977:295). Many authors have reported similar kinds of parties among feral goats (Riney & Caughley, 1959; Asahi, 1960; Yocom, 1967; Crook, 1969; Rudge, 1970; Shank, 1972; McDougall, 1975; Shikano, in prep.). It is obvious that the fundamental composition of the Turkana goat parties is similar to that of wild and feral goats.

A notable characteristic of the Turkana goats is the individual variation in the closeness of mother-offspring bond. Some pairs do not exhibit apparent proximity relationships. It is also striking that it is not always the youngest offspring that has the strongest attachment to the mother. These traits can be attributed to the influence of human, that is, these behavioral traits are managed behavior (Fig.1). Let us more closely examine the Turkana's management system to discover the source of these behavioral modifications.

Female goats are milked usually for 5-7 months after parturition. The kids stay at the village in the daytime while their mothers are grazing. This practice originated primarily in the people's desire to obtain milk production. Milking is usually done twice a day, in the morning and evening. Even when a female gives little milk, her kid is kept at the village if it is too small to follow on a long day's herding. Furthermore, when a Turkana family owns too many goats to manage effectively in one herd, the goats are separated into two herds according to age, one for adults and one for young. The maximum number of goats which can be easily controlled by two or three herders is between 250 and 350.

When the people set up two herds, they also build a kraal at the village for each herd. A mother and her kid will be separated into different herds. Young goats are transferred into the adult herd sometime after male castration and female parturition. The period of mother-offspring separation is at least one and a half years after birth, although they have a chance to meet while the mother is milked. The people do not intend to modify the mother-offspring bond by these management techniques, but the bond is weakened in some pairs. This practice of separation produces individual differences in the degree of proximity between a mother and her offspring.

The most remarkable behavioral change brought about in the goats by man's management is that all the goats of one herd are familiar with one another. A goat discriminates sharply between those goats which belong to its herd and those which do not, and the unity of the herd is based on this recognition. It was stated that particular proximity relationships do not exist in every mother-offspring pair. Offspring do not always maintain close proximity to their mothers, even when they graze with their mothers more frequently than with the other members of the herd. Some offspring do not follow their mothers while grazing, although they recognize which are their mothers.

The mother-offspring bond is loose because it is supplemented by the bond with other herd members. In the small parties formed by goats while grazing, an individual may be relaxed because it is surrounded by familiar goats of the same herd. Goats prefer to stay in larger parties, however, and when the party is too small for the individuals to feel relaxed, they will stop grazing to raise their heads, and look around for their companions. Through this process, the goats of one herd assemble together into larger parties without herder's command.

The Turkana are aware of the cohesiveness of herd members, although they have no explicit management techniques to increase cohesiveness. However, the bond between specific individuals (mother and offspring) is replaced by the bond between unspecific individuals. This change results from the management in that the goats of a herd are herded together during the day and put together in one kraal at night.

This conclusion is reasonable when we consider the composition and fluctuation of herd members. Among the Turkana, goats are frequently slaughtered or exchanged between families. Day-trip herding is performed in a society where there are frequent changes in the herd membership.

3. Autonomous movement of the goats

Day-trip herding has two turning points, watering and resting, when all the goats of a herd are gathered together. As shown in Observation 1, goats sometimes proceed in certain directions at certain times, as if they were anticipating the daily cycle of herding. The goats are clearly able to choose the "right" direction by themselves.

Autonomous movement of the goats can be observed throughout a day of herding. Their choice of the right direction is most evident twice a day, when proceeding toward the watering spot in the morning, and when returning to the village in the evening. When the goats begin to graze again after several hours of rest, the animals themselves initiate the departure. The herder's commands stop the goats when they stand up too early. The goats are observed not only to select the direction to proceed, but also to sit down, without commands from the herders after arrival around the village, and watering and resting spots.

This behavior, and the cohesiveness of the herd, significantly reduce the herder's labor. In accordance with the autonomy of the goats' movements, the nature of the herder's control can be summarized as follows:

(1) primary selection of a course after departure from the village, watering and resting spots,
(2) suppression of movement initiated by the goats too early,
(3) herding the goats in a clump before arrival around the village, watering and resting spots.

The goat's familiarity with the herding area may not be the result of behavioral modification by management, since the existence of home ranges has been reported among feral goats (Riney & Caughley, 1959; Yocom, 1967; Shikano, in prep.). Certain mechanisms control the goat's daily rhythms. First, the goat's concentration at the watering spot can be explained by the physiological factor of thirst. On the day after the heaviest rain of the study period, goats were not observed to assemble at the watering spot. On that day, the goats did not seem to be thirsty, because their food plants may have contained enough water, and because it was cloudy. The goat's daily rhythm was interrupted and the herders had to work hard to round the goats up to the watering spot.

As for resting at mid-day, feral goats are reported resting once or twice a day during daylight (Yocom, 1967; McDougall, 1975). According to Schaller (1977), wild goats retire to the shade of trees or rocks when the temperature is high in the daytime. Considering that the habitat of the Turkana is arid semi-desert, their goat's behavioral pattern of resting in the daytime may be directly traced to the behavioral pattern of non-managed goats. The autonomous departure from the resting spot for grazing suggests that these goats are resting according to their natural daily cycle.

But how do they assemble at a specific spot? They concentrate at a fixed place, although there are many trees in the herding area that give shade comfortable for resting. This behavior is originated in man's management: the most convincing interpretation is that they have been trained and learned the spot. The same interpretation may apply to their concentration at the fixed watering spot. Originally, the goats were gathered at a certain specific spot, which was learned and became fixed in the daily cycle of the herd. The tradition was passed on to newborns and newcomers through repetition during the day-trip herding.

Table 10. Number and categories of goats which came back to the village earlier than others

(a) first period

date (1980)	F*	F	Fm	Fy	Mc	Mm	My	total
1. Oct. 12	2		1				1	4
2. Oct. 16	8	6	7		1	2		24
3. Oct. 17	10	10	12	2	1	2	1	38
4. Oct. 23	5	1	7	4	1			18
total	25	17	27	6	3	4	2	84

(b) second period

1. Dec. 4	21	1	1					23
2. Dec. 5	15	2			1	1	1	20
3. Dec. 10	2	5						7
4. Dec. 11	7	1		1				9
total	45	9	1	1	1	1	1	59

χ^2=15.1, $p<0.001$ for the first period.
χ^2=17.4, $p<0.001$ for the second period.
F*, females which have kids at the village. Females which delivered in Sept. and in Nov.-Dec. 1980 are classified as F* in first and second periods respectively. For other goat categories, see Table 1.

Finally, the goat's returning to the village should be discussed. A few females which had new borns returned to the village significantly earlier than the other parous females (Table 10). These mothers returned in the evening, after slipping away from the herd which was 100-200 m from the village. These females were attracted by their kids, and were followed by a few goats.

However, the entire herd did not follow the mothers back to the village, but remained wandering nearby. It was observed that goats besides the mothers with kids at the village autonomously headed toward the village in the afternoon. They were not led by the mothers. The mothers were not observed running into the village about one month after parturition, even when they approached nearby and the kids bleated loudly. In this period, the mothers did not return to the village for their kids. My observations indicate that it is rare for a part of the herd to run into the village.

The homing behavior may account for this phenomena, since goats regard the village as their sleeping place. Schaller stated for wild goats that "[they]...return to the same precipices at night" (1977:178), and Coblentz (1976) reported that feral goats have certain bedding grounds to which they return in the evening. According to Asahi (1960), feral goats spend the night in ruined trenches and houses, although these are not fixed places. Goats choose sleeping places which are suitable, both physically and psychologically, as protection against weather and natural enemies.

The observations suggest that, for the goats of the Turkana, the village is a distinct place offering psychological comfort. The kids are kept near the village for about three months; in the daytime they wander about freely in and outside the village, in a compact group, without a herder. When frightened, they frequently rush into the village in a tight

bunch. After entering the village, they stop running and scatter to graze and play together. The village is a place of refuge and peace for the kids.

Goats regard the kraal as a special place for sleeping. When a newcomer (castrated male) was placed with the herd in the kraal one evening, he provoked strong curiosity and was attacked by the other males. Because they react indifferently to stray animals while grazing, it is evident that the goats consider the kraal as a distinct sphere. The habit that the Turkana goats regard the village as their sleeping ground, can be attributed to the Turkana's management method in which goats are kept at the village in their early stages of development, and later, forced to spend every night in the kraal.

The goats' familiarity with the area is evident in their autonomous movement patterns. Problems would arise, if the herding area was altered frequently by incessant shiftings of the village, because the goats would not be able to establish familiarity with a certain area. However, I believe that the goats can easily learn the position of the village where they spend each night, and that they quickly become familiar with the herding area.

CONCLUSION

In this paper, day-trip herding was chosen as the chief illustration of the mutual interaction between man and domestic animals, for the examination of a development mechanism for interaction. The day-trip herding of goats is easy for the Turkana because the herders do not have to continually chase and round up the goats. Certain behavioral changes in the goats, caused by the human management system, reduce the herder's labor. The modifications are: (1) individual differences in the closeness of the mother-offspring bond, (2) mutual familiarity among the members of one herd, (3) formation of large groups in the phalanx phase, and (4) autonomous movement of the herd.

The key aspect of the management system that caused these behavioral modifications in the goats is that the people keep the kids at the village. Although this practice is not directly aimed inducing a change in the goat's behavior, it does exert a profound influence that makes the daily herding easier. In short, it is a secondary, unintentional result. The kids, kept in a cluster in the kraal, become conditioned to clustering, which would ordinarily cause stress in natural situations. It becomes a habit to associate with goats other than their mothers.

Among feral goats, it has been reported that pregnant females segregate themselves from the group and lead solitary life for several days after parturition (Crook, 1969; Geist, 1960; Yocom, 1969; Rudge, 1970). Under the Turkana management system, the mothers do not need to withdraw, to protect kids from others or to stay with kids of limited mobility, because the kids are kept at the village. The phase of the female's isolation from the group, which occurs in the wild, non-managed situation, does not occur in the Turkana goats, although the detailed ethological mechanism remains unspecified.

Another practice which induces a favorable modification is the repeated day-trip herding. All the herd members of one herd are familiar with one another because they are put in the same kraal every day. A goat maintains its psychological stability near any of the herd members and does not need to be near its mother. The identity of particular individuals within the herd does not matter, it is only important that they are members of the same herd. The autonomous movement of the herd is passed on to each new generation through the repetition of daily herding. The

kids are socialized in a herd which already has a daily herding rhythm.

Since the Turkana castrate most of the males, there are only a few reproducing males in the herd. Large castrated males stay in larger assemblages than the reproducing males. They graze together with females and small males. The castration of males increases the herd's unity. Fightings for females may be reduced. The goats, however, instinctively establish rank order among males to maintain orderly society in the breeding season (Schaller, 1977). Frequency of fightings among large males is low in non-managed situation (Shank, 1972). While male castration increases the herd unity, it has only little function in day-trip herding. It should be noted that the herd disperse into small parties during herding, and that there are many non-castrated matured males in the Turkana goat herds.

Day-trip herding is sustained by the total habituation of the goats. The Turkana's management system does not have specific herding techniques. However, the modifications in the goats behavior are fundamental to day-trip herding. Since behavioral changes in the goats are the result of man's unconscious, indirect functional management, the relationship between man and domestic animals should be understood as an "integrated outcome" of interspecific mutual interactions.

NOTES

*1 "Domestic animals" refers to pastoral livestock species (Krader, 1969).

*2 This paper considers only goat herding. For information on other aspects of Turkana stock management, such as husbandry, see Gulliver (1951) and Ohta (1980).

*3 In this paper, "herd" indicates a group of goats managed as a unit during day-trip herding and enclosed within one kraal at night.

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REFERENCES

Asahi, M., 1960. On the free-ranging herd of Tokara goats in Tomogashima Island. Physiology and Ecology, Japan, 9:44-52. (in Japanese)

Baskin, L. M., 1974. Management of ungulate herds in relation to domestication. ICUN Publications new series, 24:530-541.

Coblentz, B. E., 1976. Wild goats of Santa Catalina. Natural History, 85:71-77.

Crook, I., 1969. Feral goats of North Wales. Animals' Magazine, 12:13-15.

Geist, V., 1960. Feral goats in British Columbia. Murrelet, 41:34-40.

Gregersen, E. A., 1977. Language in Africa: An Introductory Survey. Gordon and Breach, New York.

Gulliver, P. H., 1951. A Preliminary Survey of the Turkana. Cape Town University, Cape Town.

Hale, E. B., 1969. Domestication and the evolution of behavior. In: The Behavior of Domestic Animals (2nd ed.). E. S. E. Hafez (ed.), Bailliere, Tindall & Cassell, London. pp. 22-42.

Krader, L., 1969. Pastoralism. International Encyclopaedia of Social Science, 11:453-461

McDougall, P., 1975. The feral goats of Kinderhead Moor. Journal of Zoology, 176:215-246.

Ohta, I., 1980. Property unit and nomadic unit of the Turkana. In: A Study of Ecological Anthropology on Pastoral and Agrico-Pastoral Peoples in Northern Kenya. J. Tanaka (ed.), Kyoto University Primate Research Institute, Inuyama. pp. 55-77.

_____, in press. Man-animal relationship in cattle management of the farmers in Oki Islands, Japan. In: Comparative Studies of Pastoral Societies. Y. Tani & K. Fukui (eds.). (in Japanese)

Riney, T. & G. Caughley, 1959. A study of home range in a feral goat herd. New Zealand Journal of Science, 2:157-170.

Rudge, M. R., 1970. Mother and kid behavior in feral goats (Capra hircus L.). Zeitschrift Tierpsychologie, 27:687-692.

Schaller, G. B., 1977. Mountain Monarchs. The University of Chicago Press, Chicago.

Shank, C. C., 1969. Some aspects of social behaviour in a population of feral goats (Capra hircus L.). Zeitschrift Tierpsychologie, 30:488-528.

Shikano, K., in prep. Grouping and ranging patterns of feral goats in Chichi-jima, Ogasawara Islands.

Takasaki, H., 1981. Does Chrysozephyrus ataxus oviposit at random? Satsuma, 30:131-137. (in Japanese)

Tani, Y., 1976. On the pastoral culture: Interactions between the herder and livestock, and its metaphor. Zinbungakuho, 42:1-58. (in Japanese)

_____, T. Matsui & S. Omar, 1980. The pastoral life of the Durrani Pashtun nomads in northeastern Afghanistan. In: Preliminary Report of Field Survey on the Agrico-Pastoral Peoples in Afghanistan, 1978. Y. Tani (ed.), Research Institute for the Humanistic Studies, Kyoto University, Kyoto. pp. 1-31.

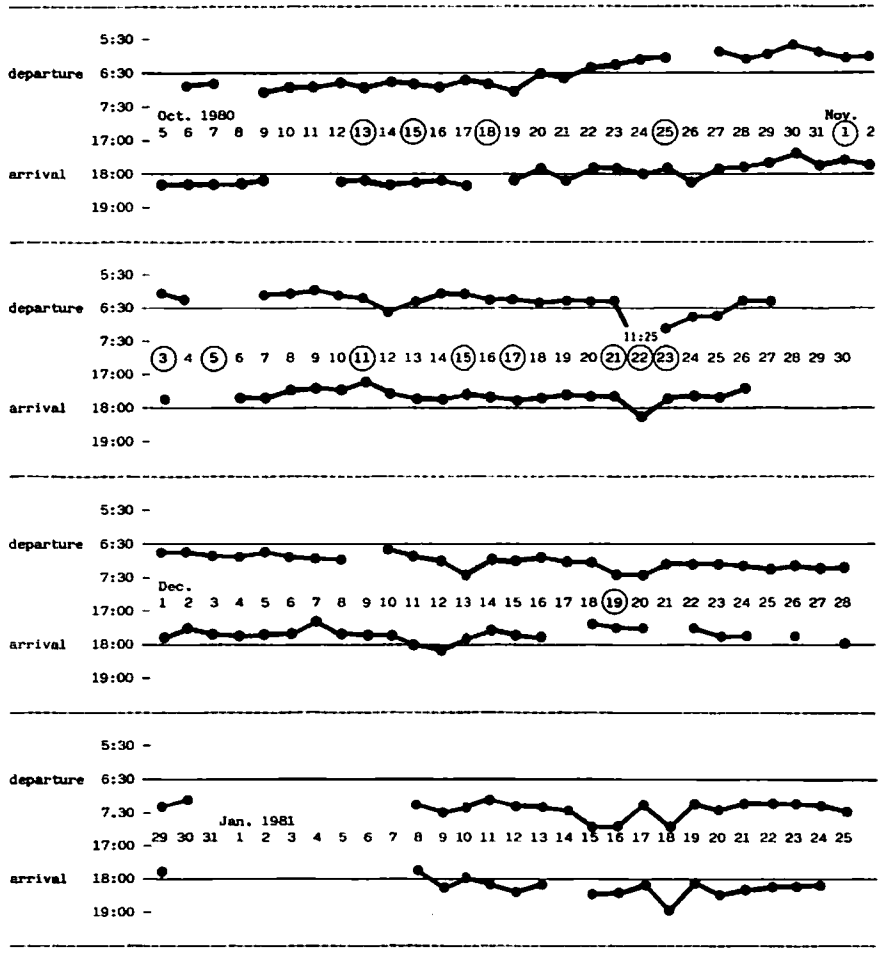
Umesao, T., 1951. Milk and Mongolian life (2): Milking and pasturing. Nature and Culture, 2:119-172. (in Japanese)

Yocom, C. F., 1967. Ecology of feral goats in Haleakala National Park, Maui, Hawaii. American Midland Naturalist, 77:418-451.

Appendix 1. Herding time transitions

Variations in the herding time, from the 15th to the 18th of January 1981, were caused by funeral rituals for the head of the family. The delay of departure time on 22 November 1980 was due to the heaviest rain of the study period, lasting from 6:15 to 11:20. Departure time is usually not affected by light rains.

In early and middle October, when the weather was driest, both departure and arrival were late. From late October to early November, when the fruit of Acacia tortilis ripened and fell at night, the goats were driven out earlier because of competition among nearby families for the fruit. Herding time was reduced in December, with departure late in the morning and earlier return. Grasses and herbs, newly sprouted after the rains in October and November, were exploited effectively in this period. After about one month, these plant species withered. In late January 1981, the herding pattern returned to that of October 1980.



○, rainy days.

Appendix 2. Goat food plant (1980)

Data were collected during the focal animal sampling, and the plant species eaten by the target goat were recorded at 5 minute intervals. The study period is divided into two parts because of the change in vegetation caused by the short rain.

In the first part, over 85% of the goat's food came from 4 plant species. These four species are major plants growing in the riverine forest and flood plain. Goats ate the flowers and leaves of Acacia tortilis and A. elatior that had fallen down to the ground. These plants provide food for the goats even in the dry season. As for Calotropis procera, the goats preferred to eat the flowers, standing up on their hindlegs to push down the stalks. Withered and fallen pericarps and leaves were also eaten, or the leaves were eaten directly off the plants. This hardy evergreen plant is utilized in the worst and driest season, although goats are not very fond of eating it, along with Cadaba rotundifolia. Salvadora persica leaves and fruits are eaten directly from the plants.

Grasses, herbs, and young buds of deciduous trees and shrubs sprouted after the short, intermittent rainy days. The number of plant species eaten by the goats increased and the herding area expanded out of the riverine forest. The new grasses and herbs withered in mid-January, 1981, but such shrubs as Dicliptera albicaulis and Seddera hirsuta remained green for several more weeks and comprised the main food plant species.

Although goats are said to be browsers, they eat grasses and herbs when available. The most important aspect of the goat's food habit is that it has a wide range of adaptability, so the goats can survive fluctuations in vegetation.

plant (vernacular name)	No. of observation					
	Oct.-Nov.		Dec.		total	
1. *Acacia tortilis (itir)*	224	33.4%	18	8.7%	242	27.6%
2. *Calotropis procera (atezulo)*	140	20.9	22	10.7	162	18.5
3. *Acacia elatior (esanyanait)*	124	18.9	5	2.4	129	14.7
4. *Salvadora persica (ethokoni)*	93	13.9	6	2.9	99	11.3
5. *Cadaba rotundifolia (epuu)*	33	4.9	1	0.5	34	3.9
6. *Hydnora* spp. *(lolimoshi)*	28	4.2	3	1.5	31	3.5
7. *Dicliptera albicaulis (emekui)*	18	2.7	42	20.4	60	6.8
8. *Ziziphus mauritiana (yakalale)*	5	0.7	4	1.9	9	1.0
9. ? *(eteteleit)*	4	0.6			4	0.5
10. *Grewia tenax (yongomo)*	2	0.3	3	1.5	5	0.6
11. *Tribulus* spp. *(esuguru)* & *Tragas* spp. *(esurumachadai)*			41	19.9	41	4.7
12. *Boerhavia erecta (yakarapat)*			30	14.6	30	3.4
13. ? *(edya)*			12	5.8	12	1.4
14. *Seddera hirsuta (lomanang)*			10	4.9	10	1.1
15. *Cordia crenata (ebitiwozin)*			5	2.4	5	0.6
16. *Ricinus communis (ebune)*			1	0.5	1	0.1
17. *Cordia sinensis (edome)*			1	0.5	1	0.1
18. *Indigofera* spp. *(etola)*			1	0.5	1	0.1
19. *Cyperus* spp. *(ekekeryau)*			1	0.5	1	0.1
total	671		206		877	

Appendix 3. Information on each goat of the study herd

1. Sexual maturity: information whether a goat had matured was acquired by interview with the Turkana. Sexually matured animals are able to reproduce, i.e. males can serve and females can conceive. Some matured goats may have been classified for immatures because of the limited terminology of the Turkana language. Those females that had aborted, and had not yet been mothers, are not included in the category of parous females.

2. Castration: The Turkana castrate most of their male goats, except a few reproducing males. The castration is performed after the goats reach maturity. Young matured, non-castrated males were sometimes observed to copulate with females. However, the Turkana distinctly discriminate those males from reproducing males and each category has a different classificatory name.

3. Age in October 1981: The goat's age was determined by teeth examination in October 1981, at the time of the supplementary study. Goats which had already developed the second set of one incisors (I_1) were classified as 1 year old; I_2 and I_1 as 2 years old; I_3, I_2, and I_1 as 3 years old; I_4, I_3, I_2, and C as more than 3 years old. The age of goats which were not in Oct. 1981 were estimated by asking the Turkana which other goats were born at the same time.

4. Family: Goats of matrilineal kin relation constitute a family. Information on kin relations were obtained by interviews with the Turkana. Goats α and β were regarded to belong to different families when they were informed to be related via more than 2 goats which were not present at the study period owing to transfer or slaughter. The families are symbolized by letters, A, B,...Z, a, b,...w. The goats with the family symbol x have no kin related goats in the study herd. Kin relations among goats in a family are indicated as follows: (1) A1, A2, A3,... are siblings, the goats with lower numbers being older, (2) A11, A12,... are A1's offspring, with older offspring having lower numbers.

a, M; b, Mc; c, Mm; d, My; e, F; f, Fm; g, Fy; (for the symbols of goat categories, see Table 1)
h, age in Oct. 1981; 1, one year old; 2, two years old; 3, three years old; 4, older than three years;), estimated ages;
i, delivered in Sep. 1980; j, delivered in Nov.-Dec. 1980;
k, sample goats for the study of sitting position in the kraal;
#, twins; *, large males; **, goats which disappeared during the study period.

No.	goat	a	b	c	d	e	f	g	h	i	j	k
1.	A1					+			4	+		
2.	A11			+					3)			
3.	A2					+			4	+	+	
4.	A21		+						4)		+	
5.	A3					+			4	+		
6.	A4						+		2	+		
7.	A51						+		4	+		
8.	B1		+*						4)		+	
9.	B2					+			4	+	+	
10.	B21						+		4	+	+	
11.	B22								3	+		+
12.	B31								3	+		+
13.	C1							+	4		+	
14.	C2							+	4	+		
15.	C3								3	+		
16.	C41							+	4		+	
17.	C411							+	4	+		
18.	C412							+	2)			
19.	D1							+	4			
20.	D2						+*		4)			+

(continued 1)

21.	D31			+		4	+		+		71.	K11				+		3		+	+			
22.	D311				+	3		+	+		72.	L1			+			4	+					
23.	E1		+*			4)			+		73.	L11				+		3						
24.	E2			+		4			+		74.	L2		+*				4)			+			
25.	E3				+	2)			+		75.	L3				+		3						
26.	F1			+		4	+		+		76.	N1			+			4		+				
27.	F11		+*			4)			+		77.	N11				+		3						
28.	F12			+		4		+	+		78.	N2			+			4)						
29.	F121**		+			4)			+		79.	O1			+			4	+					
30.	F122				+	3			+		80.	O11				+		4		+				
31.	F13			+		4		+	+		81.	P1			+			4	+					
32.	F14#**			+		3)			+		82.	P11			+			4	+					
33.	F15#			+		3			+		83.	P12				+		4						
34.	F2			+		4		+	+		84.	P13					+	2)						
35.	F21			+		4		+	+		85.	Q1			+			4						
36.	F211				+	3		+	+		86.	Q2				+		4)						
37.	F22			+		4			+		87.	R1			+			4			+			
38.	F23		+			3)			+		88.	R11**		+*				4)			+			
39.	F3			+		4					89.	R12				+		3			+			
40.	F31			+		4		+	+		90.	R13**					+	2)			+			
41.	F4			+		4			+		91.	R2			+*			4			+			
42.	G1		+*			4			+		92.	R3			+*			4)			+			
43.	G2				+	3					93.	R41					+	2			+			
44.	G3				+	3		+			94.	S1				+		4	+					
45.	H1			+		4		+	+		95.	S2#				+		4	+					
46.	H11		+*			4			+		96.	S3#				+		4	+					
47.	H12			+		4	+				97.	T1				+		4)						
48.	H21		+			4)			+		98.	T2					+	4						
49.	H22#				+	3		+			99.	T3					+	2)						
50.	H23#				+	3					100.	V1				+		4	+					
51.	H31			+		4		+			101.	V2				+		4	+					
52.	H32				+	3		+			102.	V3					+	3						
53.	H331				+	3		+			103.	V41					+	3						
54.	H332			+		2)					104.	W1				+		4		+	+			
55.	I1			+		4			+		105.	W11				+		4						
56.	I11**		+*			4)			+		106.	W111					+	2						
57.	I1211				+	2					107.	W12			+*			4)			+			
58.	I2			+		4		+	+		108.	W13					+	4						
59.	I21			+		4		+	+		109.	W2					+	3						
60.	I211		+			3			+		110.	X1				+		4		+	+			
61.	I22				+	3			+		111.	X11#					+	3		+	+			
62.	I31			+		4		+	+		112.	X12#					+	3			+			
63.	I311			+		4		+	+		113.	X13						+	2)		+			
64.	I312#				+	3		+	+		114.	Y1#			+*			4			+			
65.	I313#				+	3		+	+		115.	Y2#			+*			4)			+			
66.	I314		+			3			+		116.	Y3				+		4	+					
67.	I315				+	2			+		117.	Y31					+	2						
68.	J1			+		4		+	+		118.	Y4					+	3		+				
69.	J11			+		2)			+		119.	Y5					+	3		+				
70.	K1			+		4			+		120.	Z1				+		4)						

(continued 2)

121. Z11 + 3	160. m2 + 4
122. Z2 + 4 +	161. n1 +* 4 +
123. Z31 + 4) +	162. n2 + 3)
124. Z311 + 4	163. n3 + 3) +
125. Z32 + 4)	164. n4 + 2
126. Z331** + 4) +	165. q1 + 4 +
127. Z332 + 3 +	166. q11# + 4 +
128. Z41 + 4	167. q12# + 4 +
129. Z42 + 3)	168. q13** + 3)
130. Z51 + 4 +	169. q14 + 1
131. Z52 + 4)	170. r1 +* 4) +
132. Z531 + 2	171. r2 + 4 +
133. Z541 + 3 +	172. t1 +* 4) +
134. Z551# + 3	173. t2** + 2)
135. Z552# + 3	174. w1 + 4 +
136. a1 + 4 +	175. w11 + 4
137. a2#** + 3)	176. x1 + 3 +
138. a3# + 3	177. x2 + 4) +
139. b1 + 4)+	178. x3 + 4 +
140. b11 + 2)	179. x4 + 4 +
141. d1 + 4 +	180. x5 + 4
142. d11 + 2	181. x6 + 4
143. e1 + 4)+	182. x7 + 4 +
144. e2 + 4)	183. x8 + 4
145. e3# + 3)	184 x9 + 3
146. e4# + 3	185. x10 + 4 +
147. f1 + 4 +	186. x11 + 4 +
148. f2 + 4	187. x12 + 3
149. f31 + 4 +	188. x13 + 4
150. f311** + 2)	189. x14 + 4 +
151. f32 + 4 +	190. x15 + 4 +
152. f33 + 3	191. x16 + 4
153. g1 +* 4 +	192. x17 + 4
154. g2 + 3)	193. x18 + 2
155. i1 + 4 +	194. x19** + 4)
156. i11** + 2)	195. x20 + 3
157. k1 + 4) +	196. x21 + 3
158. k2** + 2)	197. x22 + 2)
159. m1 +* 4) +	198. x23 + 3